Improvements in Forecasting Regions of Aviation Hazard Impact from Advances in the HRRR and RAP models

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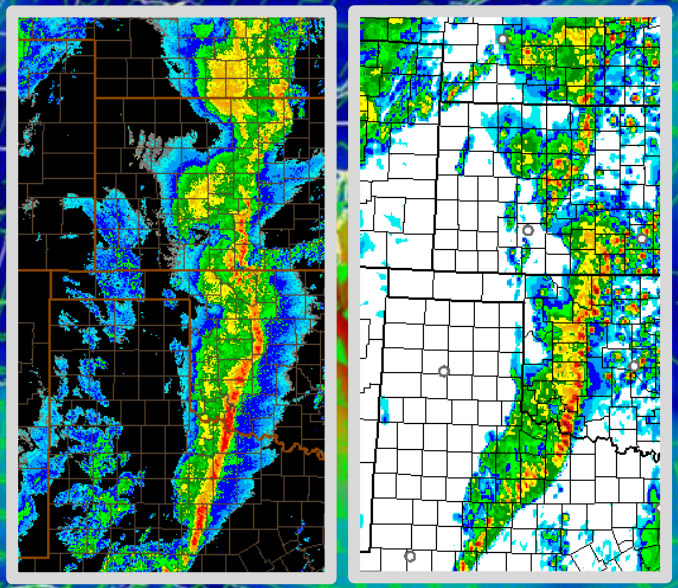

From various AMS Annual Meeting conferences
11-14 January 2016 | New Orleans, Louisiana

RAP and HRRR: Progression of enhancements

RAPV3/HRRRv2 May 2016 NCEP

- Longer forecast length (R-21, H-18)
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- Improved physics (LSM, PBL)
- Fully cycled LSM in HRRR
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Reduced warm / dry bias, improved surface and upper-air verification, better convection and winter weather

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Observations assimilated in the RAP and HRRR

New observation-types in red

Hourly Observation Type	Variables Observed	Observation Count
Rawinsonde	Temperature, Humidity, Wind, Pressure	120
Profiler – 915 MHz	Wind, Virtual Temperature	20-30
Radar – VAD	Wind	125
Radar	**Radial Velocity**	**125 radars**
Radar reflectivity – CONUS	3-d refl ➔Rain, Snow, Graupel	1,500,000
Lightning	**(proxy reflectivity)**	**NLDN**
Aircraft	Wind, Temperature	2,000 -15,000
Aircraft - WVSS	Humidity	0 - 800
Surface/METAR	Temperature, Moisture, Wind, Pressure, Clouds, Visibility, Weather	2200 - 2500
Surface/Mesonet	**Temperature, Moisture, Wind**	**~5K-12K**
Buoys/ships	Wind, Pressure	200 - 400
GOES AMVs	Wind	2000 - 4000
AMSU/HIRS/MHS **(RARS)**	Radiances	1K-10K
GOES	**Radiances**	**large**
GOES cloud-top press/temp	Cloud Top Height	100,000
GPS – Precipitable water	Humidity	260
WindSat Scatterometer	Winds	2,000 – 10,000

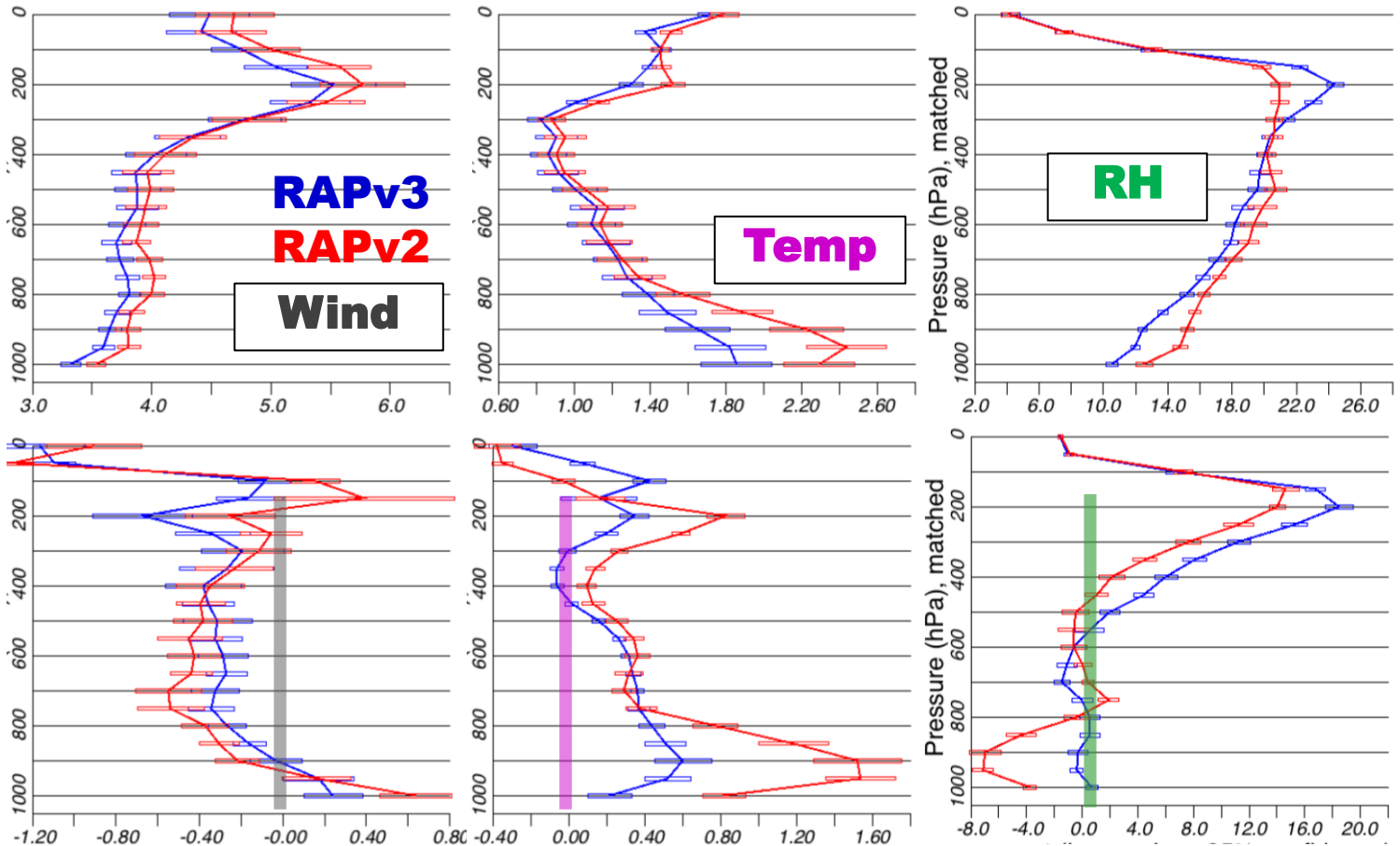
RAP and HRRR: Hourly-Updated Aviation Guidance

Wind improvement generally from increased ensemble weight

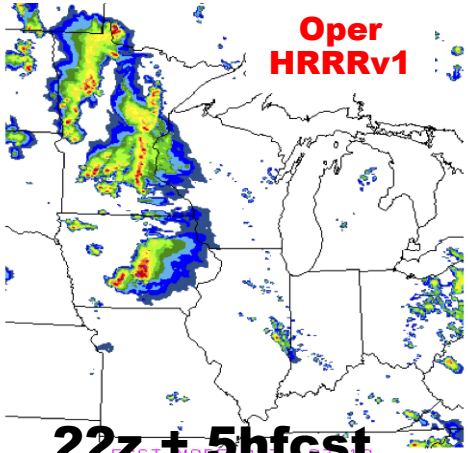
RMSE

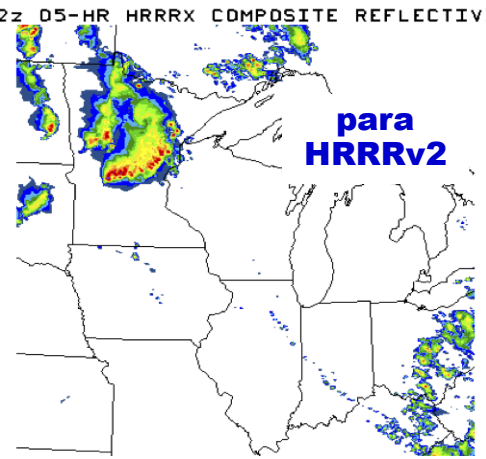
BIAS

Reduced biases from physics enhancements strong factor in temperature and relative humidity improvements



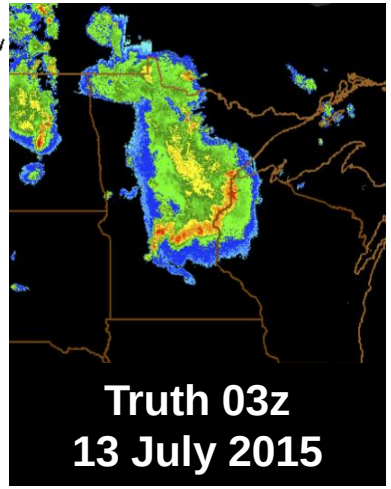
RAPv3 and HRRRv2: Improved convective forecasts

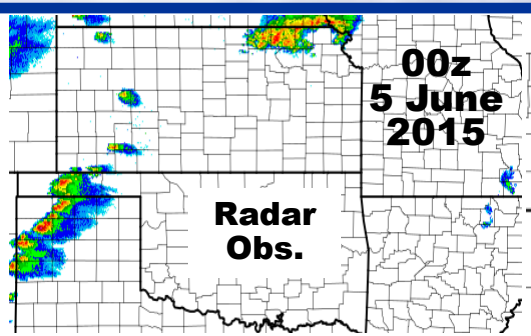


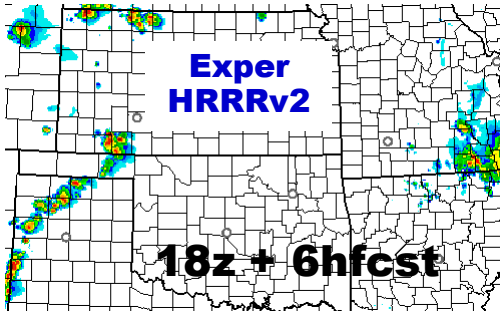


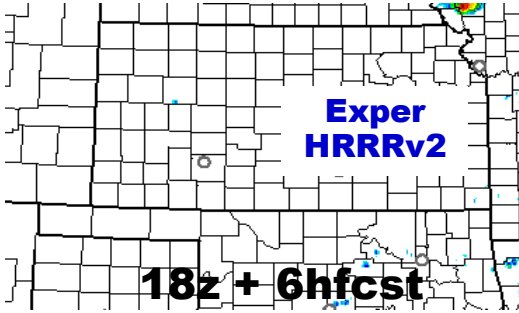
Improved convection (reduced over-prediction, better location)

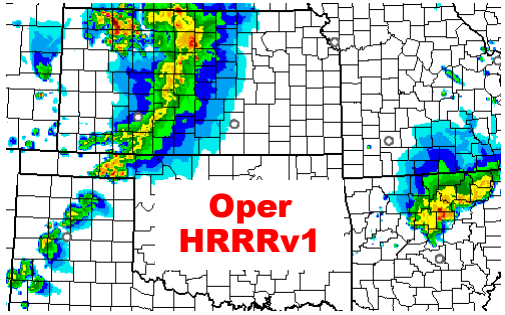
Better storm Environment from physics improvements

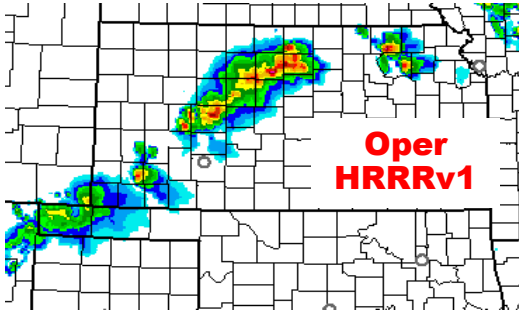




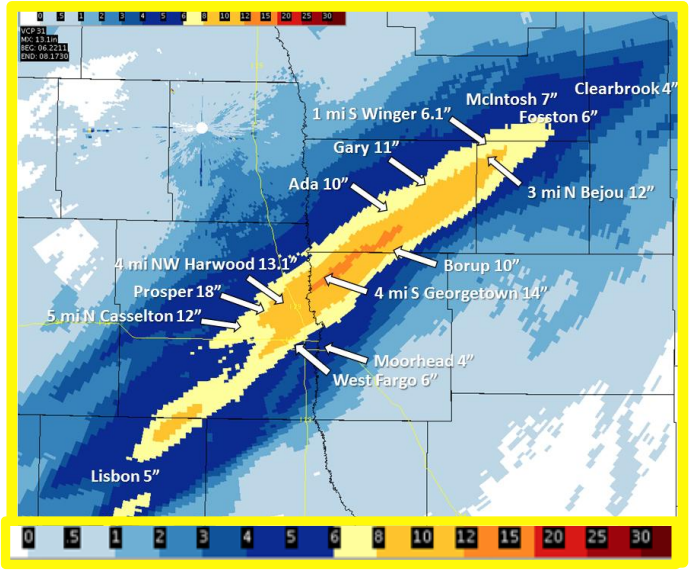




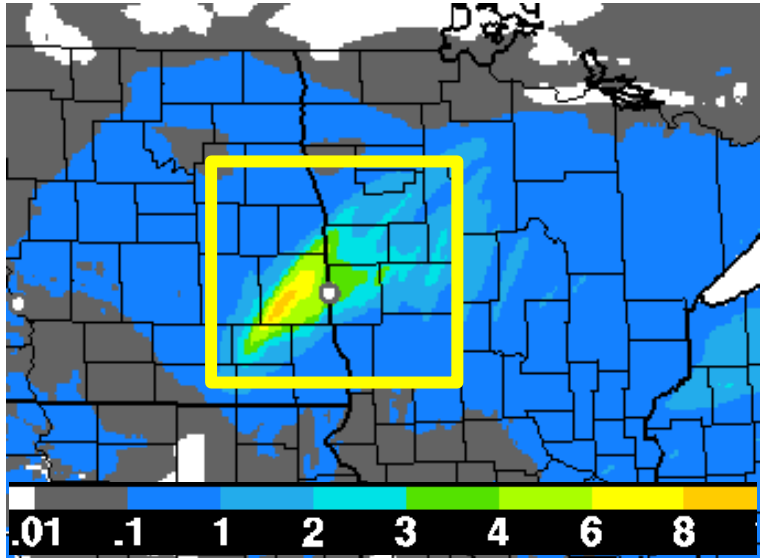




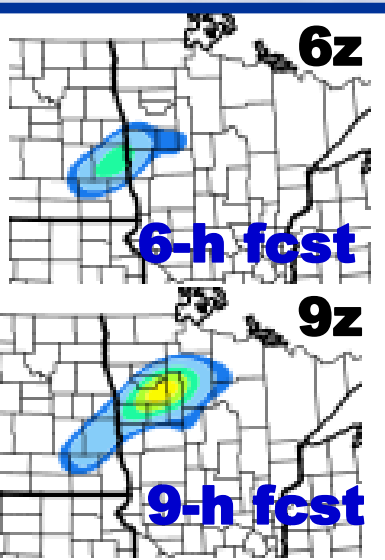
RAPv3 and HRRRv2: Excellent WINTER forecasts

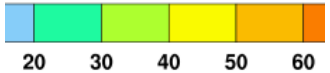


NWS observed snowfall analysis



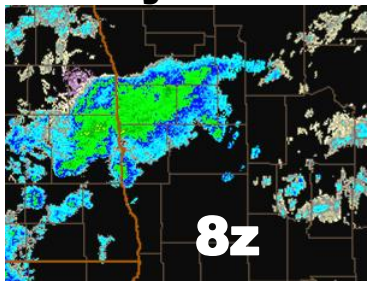
HRRRx fcst snow accum.
00z + 12h fcst valid 12Z 7 jAN

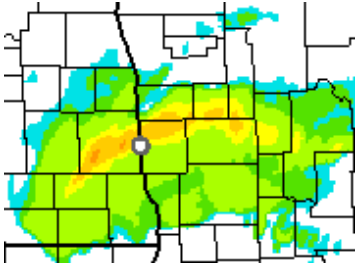




Prob > 0.5" snow / hr

Radar Obs





8z
HRRR
1-h snow

Improved winter wx guidance

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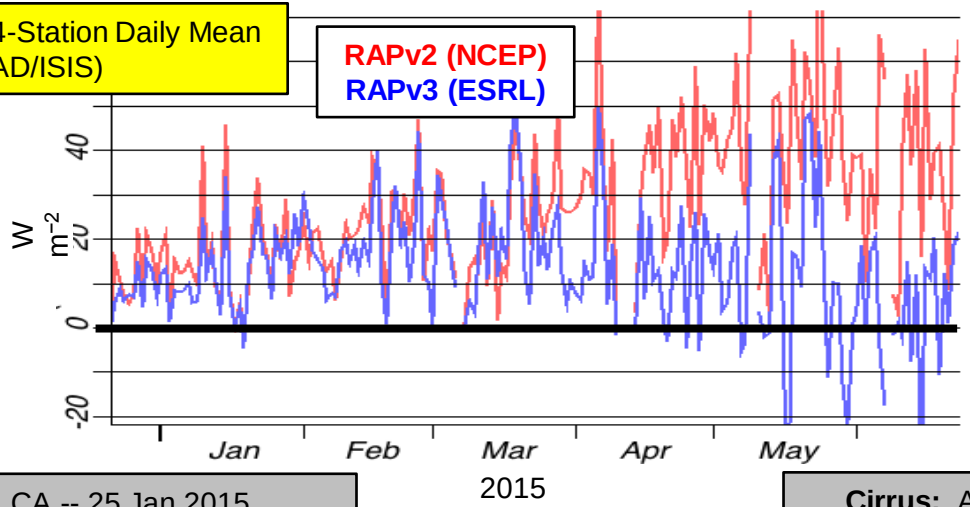
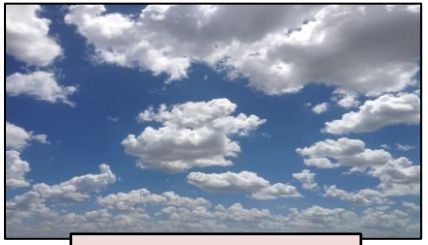
RAP Solar Irradiance (GHI) Biases

6-h Forecast Bias: 14-Station Daily Mean (SURFRAD/ISIS)

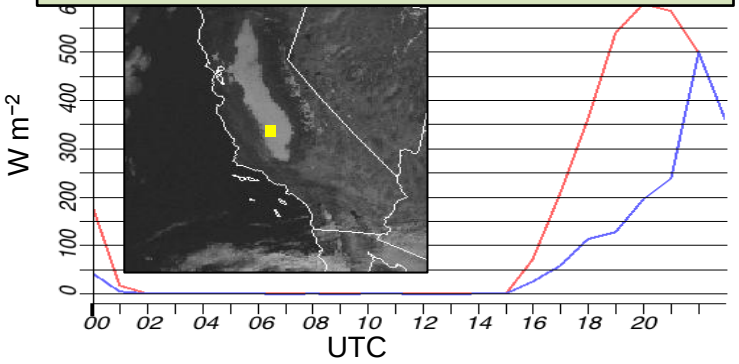




Shallow Cumulus

Stratus: Hanford, CA -- 25 Jan 2015

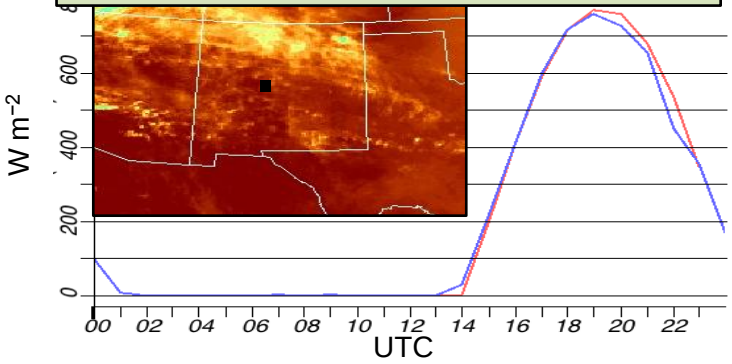
KVIS 251835Z AUTO 00000KT 1/4SM **OVC002**

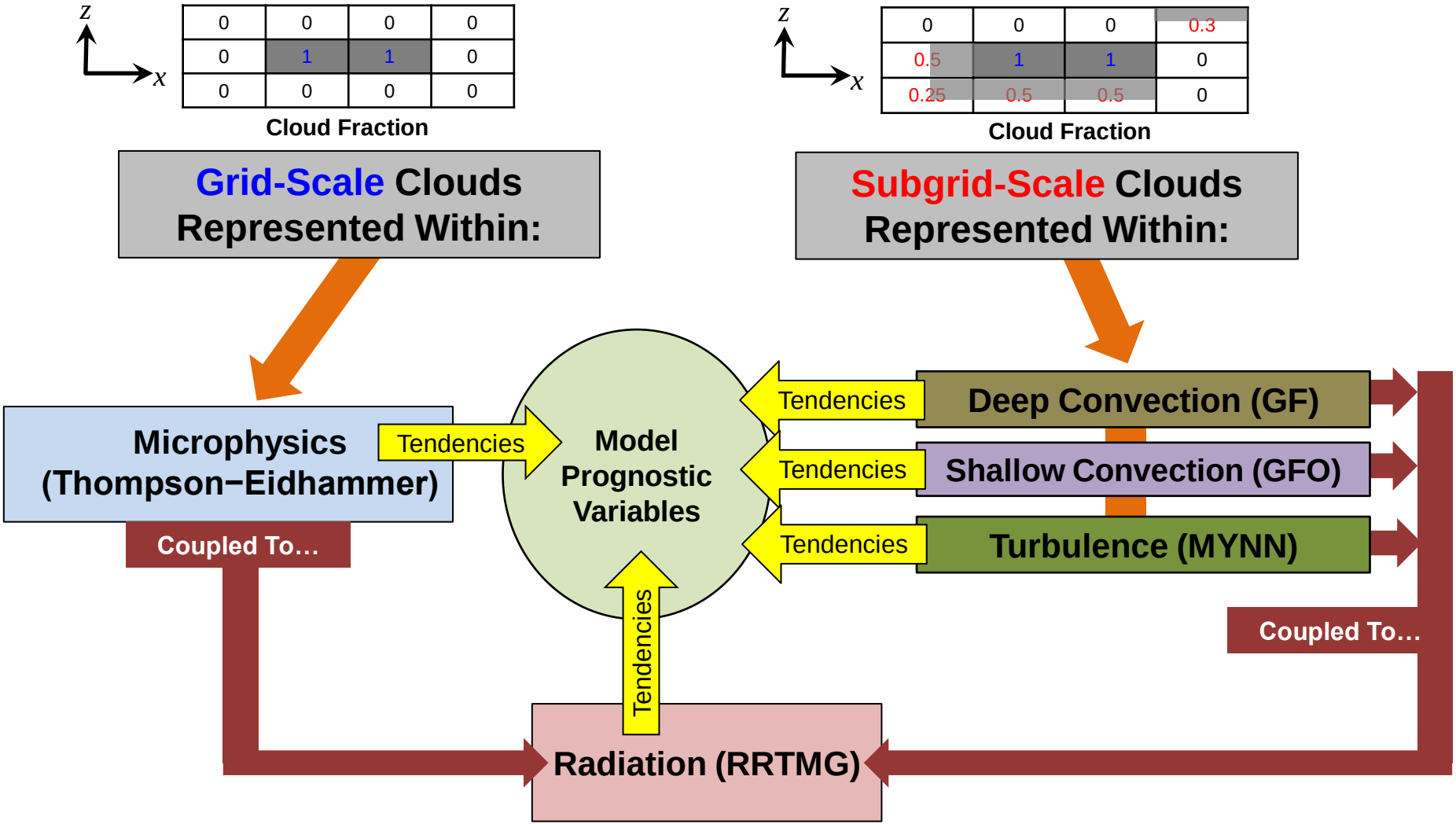


6-h Forecast: RAPv3
Measured: ISIS

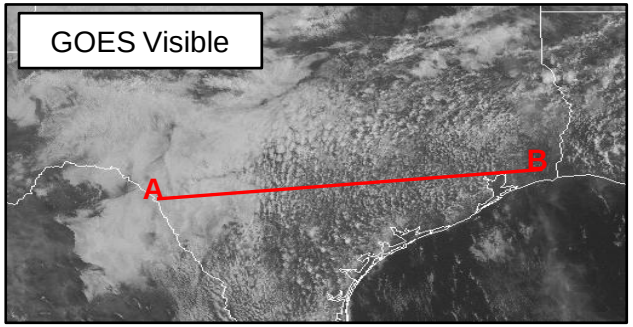
Cirrus: Albuquerque, NM -- 19 Feb 2015

KABQ 192052Z 21005KT 10SM **SCT250**

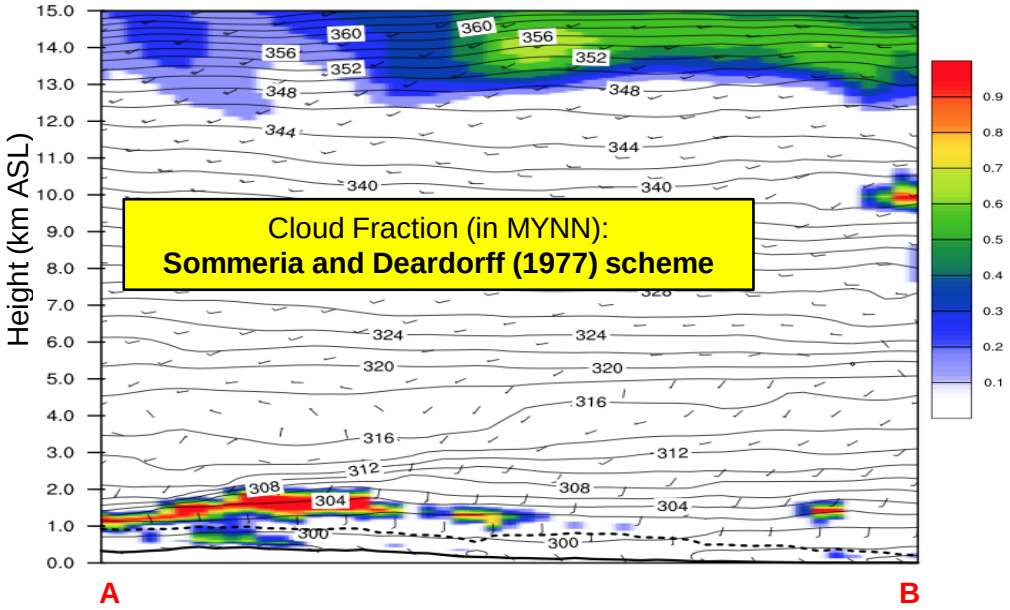


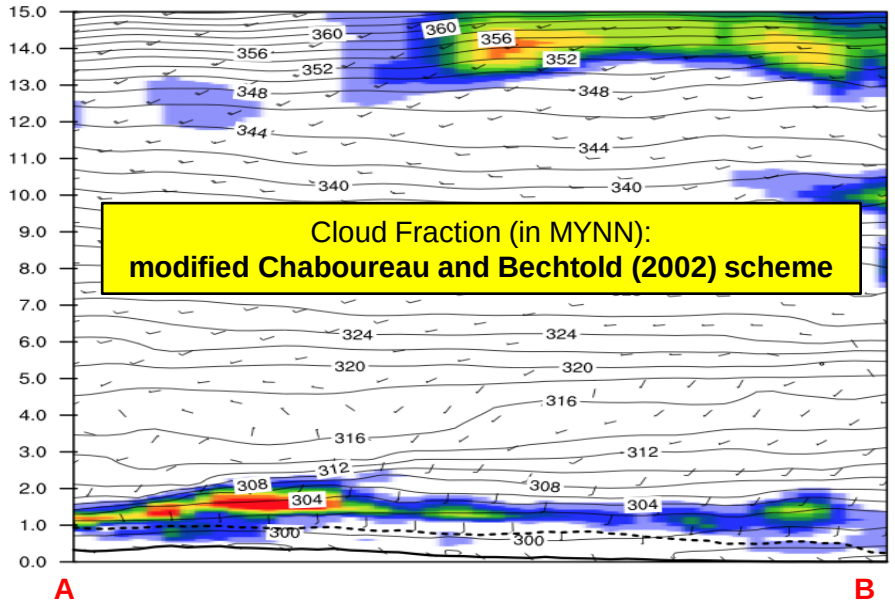

z
x
0 0 0 0
0 1 1 0
0 0 0 0
Cloud Fraction
z
x
0 0 0 0.3
0.5 1 1 0
0.25 0.5 0.5 0
Cloud Fraction
Grid-Scale Clouds Represented Within:
Subgrid-Scale Clouds Represented Within:
Microphysics (Thompson−Eidhammer)
Tendencies
Model Prognostic Variables
Tendencies
Deep Convection (GF)
Tendencies
Shallow Convection (GFO)
Tendencies
Turbulence (MYNN)
Coupled To…
Coupled To…
Tendencies
Radiation (RRTMG)

Example: RAP 3-h Forecasts Valid 1500 UTC 20 May 2015

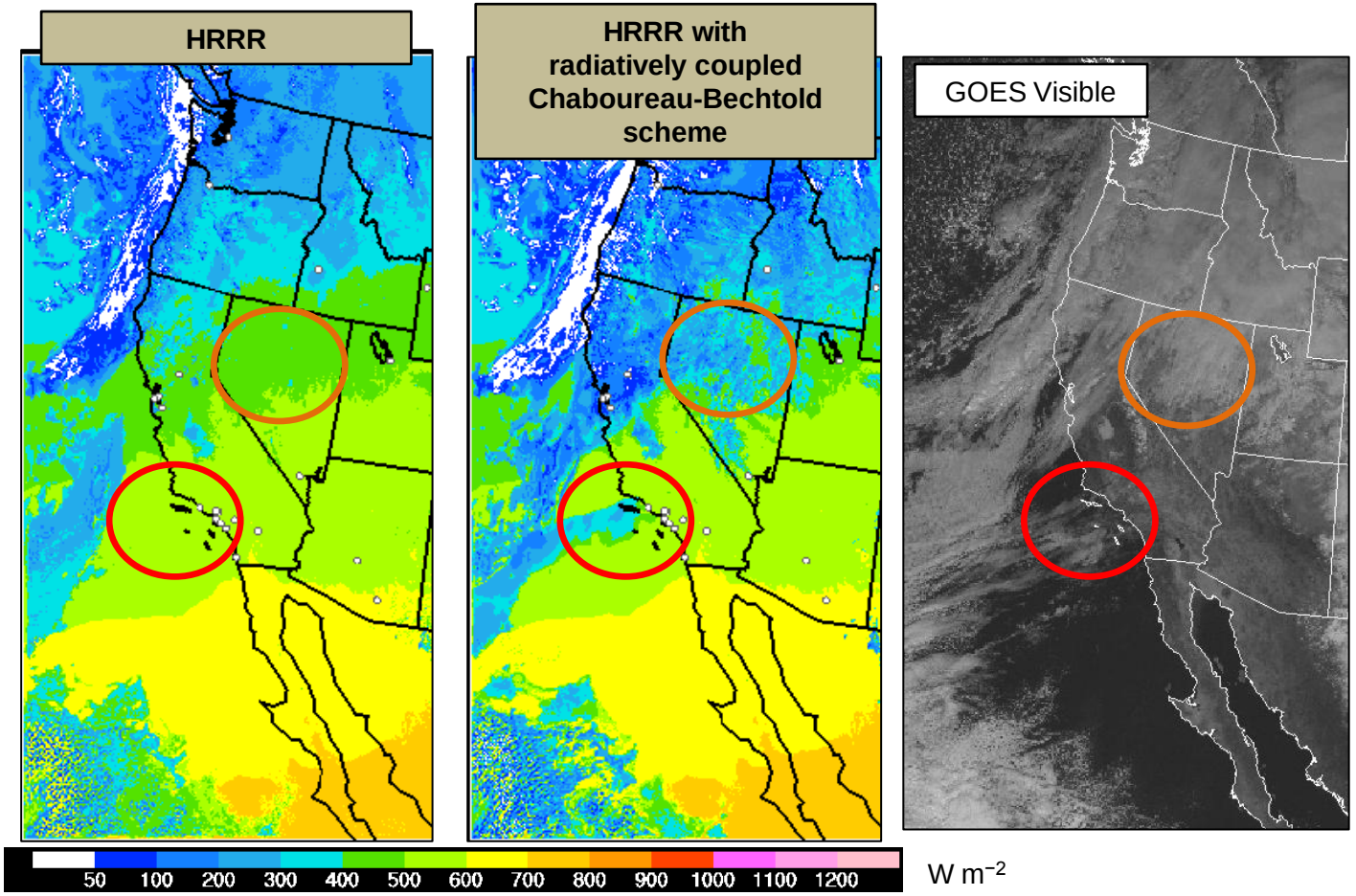


- Chaboureau and Bechtold (2002) scheme is “active” in stratocumulus, cumulus, and cirrus regions
- Better able to represent low−intermediate cloud fractions





Example: HRRR 1-h GHI Forecasts Valid 1900 UTC 27 Dec 2015

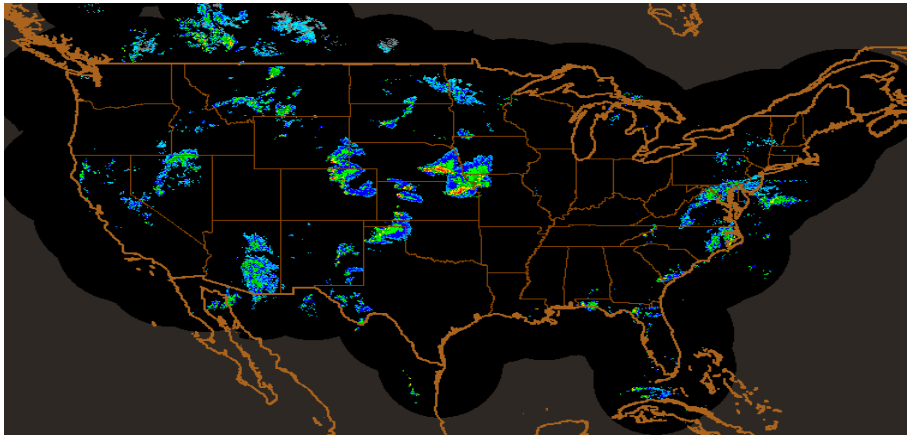


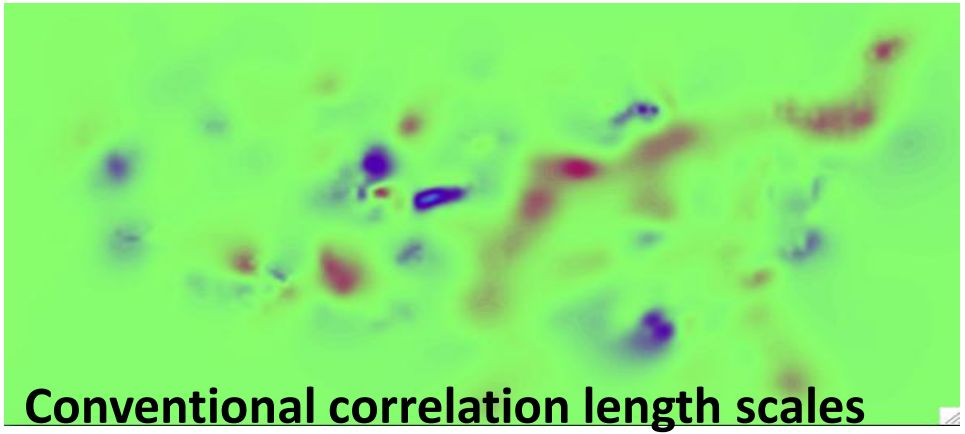
- Chaboureau and Bechtold (2002) scheme provides additional source of subgrid clouds for radiative flux forecasts

HRRR radial velocity assimilation

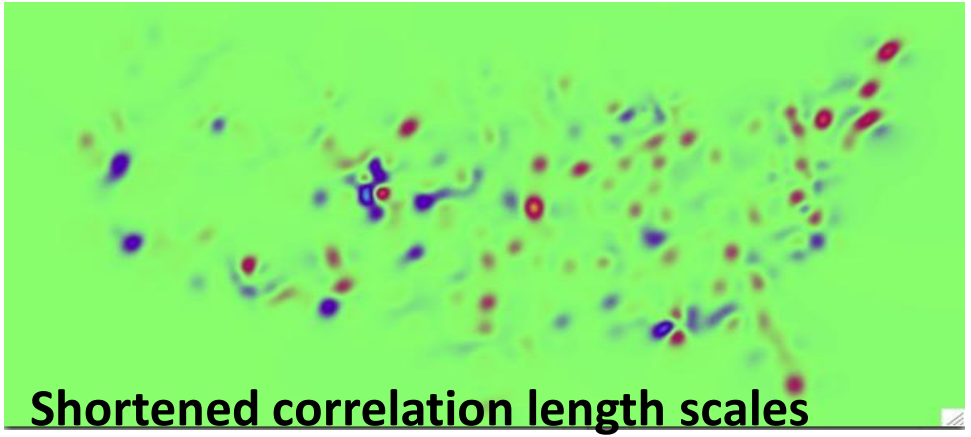
02z V-comp increments from 2nd pass of GSI (with level 2 radial velocity and VAD only)

K = 5
Max / min ~ + / - 8 m/s
blue < 0, maroon > 0)





Conventional correlation length scales



Shortened correlation length scales

HRRR: Storm-scale ensemble testing

- **Coordinated work with research community (NSSL, PSD, NCAR, CAPS)**
- **Working with both GSI and DART ensemble assimilation systems**
- **Goal to transition approaches from research to operations**
- **Current testing over smaller SE US HRRR domain (David Dowell)**

HRRR Retrospective Testing: 27 April 2011

- 40 members initialized from GFS ensemble
- Hourly ensemble Kalman filter (EnKF) data assimilation

control experiment: conventional observations only

radar DA experiment: conventional obs + MRMS reflectivity

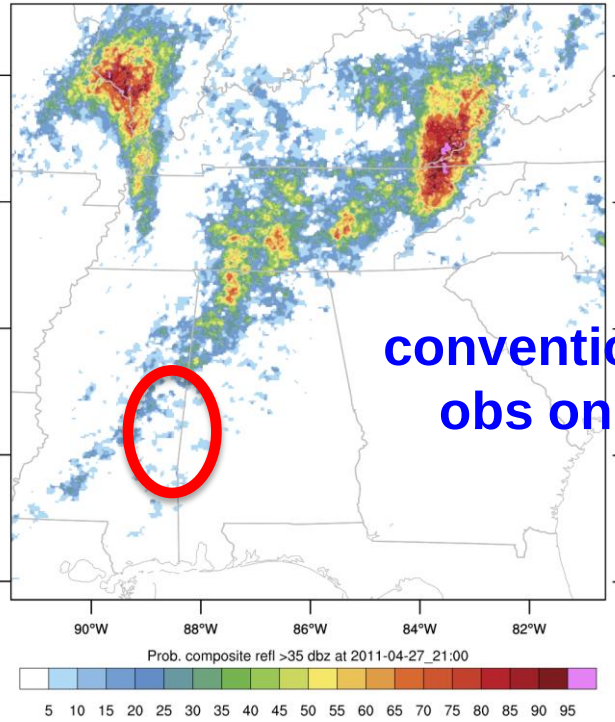
- Cycling for ~1 day, ensemble forecasts every 3 hours

ABC 33/40
Birmingham, AL

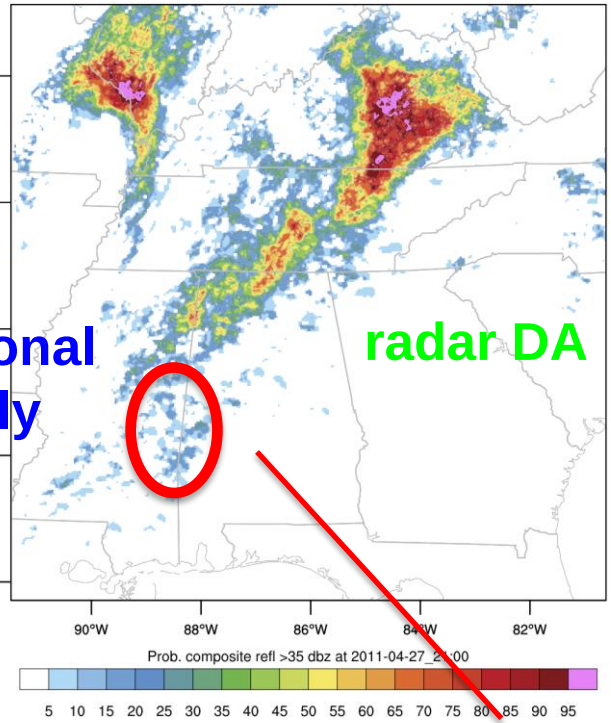
Acknowledgments: VORTEX-SE, L. Lei, J. Whitaker, H. Winterbottom, N. Yussouf

HRRR: Storm-scale ensemble testing

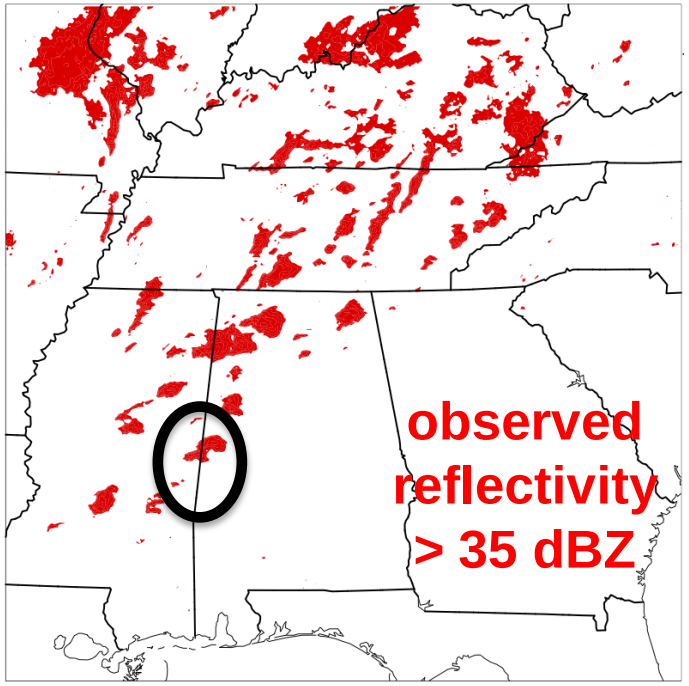
Probability of Reflectivity > 35 dBZ
3-h Ensemble* Forecast Following Cycling for 12 h



conventional obs only



radar DA



observed reflectivity > 35 dBZ

*12 Ensemble Members

Increased probability in region of developing Tuscaloosa storm

RAP / HRRR: Ongoing / future work

- **RAPv3** – Final testing at NCEP → NCEP Implement May 2016
  - Improved PBL, LSM, cu-parm, DA
  - WRFv3.6.1 w/ Thompson/NCAR aerosol-aware microphysics
- **HRRRv2** – Final testing at NCEP → NCEP Implement May 2016
  - Initialized by 2015 RAP (v3)
  - Improved radar assimilation, hybrid assimilation, PBL/cloud physics
- **RAPv4** – GSD testing in 2015 → NCEP Implement 2017
  - 3D cloud fraction, better coupling to radiation scheme, better ceilling
- **HRRRv3** – GSD testing in 2015 → NCEP Implement 2017
  - Full 3-km hourly cycling w/radial vel
  - Cycling of aerosols with fire/emissions
  - **Testing storm-scale ensemble DA**

Refining High-Resolution-Time-Lagged Ensemble (HRTLE) guidance products